JC19 Rec'd PCT/PTO 04 JUN 2001

FORM PTO-1390 (REV. 5-93)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **10191/1885**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/857335

NTERNATIONAL APPLICATION NO. **PCT/DE00/03452**	INTERNATIONAL FILING DATE **29 September 2000** **(29.09.00)**	PRIORITY DATE CLAIMED: **02 October 1999** **(02.10.99)**

TITLE OF INVENTION
FUEL INJECTION VALVE

APPLICANT(S) FOR DO/EO/US
Wolfgang RUEHLE, Hubert STIER, Matthias BOEE, Guenther HOHL, and Norbert KEIM

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other nformation.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have. been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), and PCT/RO/101.

EXPRESS MAIL NO.:

JC18 Rec'd PCT/PTO 0 4 JUN 2001

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/857335	INTERNATIONAL APPLICATION NO. PCT/DE00/03452	ATTORNEY'S DOCKET NUMBER 10191/1885

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	14 - 20 =	0	X $18.00	$ 0	
Independent Claims	1 - 3 =	0	X $80.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 860	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$860.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: [signature] (Reg. No. 41,172)

[signature]
SIGNATURE

SEND ALL CORRESPONDENCE TO:
Kenyon & Kenyon
One Broadway
New York, New York 10004

Richard L. Mayer, Reg. No. 22,490
NAME

CUSTOMER NO. 26646

DATE 6/4/01

09/857335
JC18 Rec'd PCT/PTO 04 JUN 2001

[10191/1885]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	RUEHLE et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	FUEL INJECTION VALVE
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231
Box Patent Application

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to:
--What Is Claimed Is:--.

Please cancel original claims 1 to 12, without prejudice, in the underlying PCT Application No. PCT/DE00/03452.

EL 244503965

Please add the following new claims:

13. (New) A fuel injection valve, comprising:

one of a piezoelectric actuator and a magnetostrictive actuator;

a valve needle;

a valve seat surface;

a valve closing body that can be activated by the one of the piezoelectric actuator and the magnetostrictive actuator via the valve needle and that interacts with the valve seat surface to produce a sealing seat; and

at least one damping element including a solid that exhibits an almost static behavior at a high deformation rate and is one of elastically deformable and plastically deformable at a low deformation rate.

14. (New) The fuel injection valve according to claim 13, wherein:

the fuel injection valve corresponds to an injection valve for a fuel injection system of an internal combustion engine.

15. (New) The fuel injection valve according to claim 13, wherein:

the solid of the at least one damping element includes a plastic.

16. (New) The fuel injection valve according to claim 15, wherein:

the plastic includes an uncured silicone rubber.

17. (New) The fuel injection valve according to claim 15, wherein:

the at least one damping element includes a mechanical spring exhibiting a damping behavior that is superimposed on a damping behavior of the plastic.

18. (New) The fuel injection valve according to claim 13, further comprising:

a shell;

an actuator housing including an actuator housing cover;

a prestress spring; and

a center flange, wherein:

a first face of the one of the piezoelectric actuator and the magnetostrictive actuator is supported against the shell,

the prestress spring rests with a first end against the actuator housing cover that terminates the shell to produce the actuator housing, and

a second face of the one of the piezoelectric actuator and the magnetostrictive actuator and a second end of the prestress spring are supported against the center flange.

19. (New) The fuel injection valve according to claim 18, further comprising:

a valve housing, wherein:

the at least one damping element includes a first ring-shaped damping element and a second ring-shaped damping element,

and

the actuator housing together with the one of the piezoelectric actuator and the magnetostrictive actuator contained therein and the prestress spring has a constant length and is supported against the valve housing with another first end via the first ring-shaped damping element and with another second end via the second ring-shaped damping element.

20. (New) The fuel injection valve according to claim 19, wherein:

the valve needle is connected to the center flange via a welded seam.

21. (New) The fuel injection valve according to claim 13, further comprising:

a flange; and

a cover plate, wherein:

the one of the piezoelectric actuator and the magnetostrictive actuator is supported with a first face thereof against the flange and with second face thereof against the cover plate.

22. (New) The fuel injection valve according to claim 21, further comprising:
a valve housing, wherein:
the flange is connected to the valve housing via a welded seam.

23. (New) The fuel injection valve according to claim 21, further comprising:
a valve shell; and
an actuating body supported at one end against the cover plate and being operably connected to the valve needle via the valve shell.

24. (New) The fuel injection valve according to claim 23, further comprising:
a readjusting spring; and
a flange of the valve needle, wherein:
the valve shell includes a cover plate and a base plate,
the readjusting spring and the flange of the valve needle are enclosed in the valve shell,
the at least one damping element is arranged between the flange of the valve needle and the base plate of the valve shell, and
the readjusting spring is clamped between the flange of the valve needle and the cover plate of the valve shell.

25. (New) The fuel injection valve according to claim 24, wherein:
a recess, through which the valve needle extends, is located in the base plate of the valve shell.

26. (New) The fuel injection valve according to claim 13, further comprising:
an actuating body that acts on the valve needle, wherein:
the one of the piezoelectric actuator and the magnetostrictive actuator is ring-shaped and includes a central recess through which extends the actuating body.

Remarks

This Preliminary Amendment cancels original claims 1 to 12, without prejudice, in the underlying PCT Application No. PCT/DE00/03452. The Preliminary Amendment also adds new claims 13-26. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE00/03452 includes an International Search Report, dated February 20, 2001, a copy of which is submitted herewith.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: [signature] (Reg. No. 41,172)

Dated: 6/4/01

By: [signature]
Richard L. Mayer
(Reg. No. 22,490)

One Broadway
New York, NY 10004
(212) 425-7200

FUEL INJECTION VALVE

Field Of The Invention

The present invention relates to a fuel injection valve.

Background Information

Usually changes in the length of a piezoelectric actuator of a fuel injection valve caused by temperature influences are compensated for via hydraulic devices or by selecting suitable combinations of materials.

A fuel injection valve in which the change in length of the actuator is compensated for by an appropriate combination of materials is known from German Patent No. 197 02 066. The fuel injection valve arising from this publication has an actuator that is conducted in the valve housing under spring prestress and that interacts with an actuating part made of an actuating body and a head part, the head part lying on the piezoelectric actuator and the actuating body penetrating an inner recess of the actuator. The actuating body is operably connected to a valve needle. When the actuator is set in motion, the valve needle is actuated against the direction of spraying.

The actuator and the actuating body have at least approximately the same length and are made of a ceramic material or of a material similar to ceramic with respect to its thermal expansion. The result of using materials having the same lengths and thermal expansion coefficients, e.g., INVAR, is that the actuator and the actuating body expand uniformly under the influence of heat and thus do not have an adverse effect on the opening and closing times. An undesired opening of the fuel injection valve between the switching pulses is also avoided.

The disadvantage of this arrangement is above all its limited usability in systems that are subject to large fluctuations in temperature. The arrangement known from German Patent No. 197 02 066 does not achieve the objective due to the nonlinear behavior of the temperature expansion coefficients of piezoelectric ceramics over the temperature curve. As a result, imprecise fuel metering times and amounts occur.

Another disadvantage is the high manufacturing effort required, which is associated with relatively high costs caused in particular by the selection of the materials (e.g., INVAR).

Summary Of The Invention

The fuel injection valve of the present invention with the characterizing features of the main claim, on the other hand, has the advantage that the temperature compensation is independent of the thermal expansion coefficient of the piezoelectric ceramic. The thermal expansion is compensated for via damping elements having a speed-dependent transmission behavior for arriving pulses and is thus independent of the selection of the material for the actuating element and valve housing. Thus a secure and precise method of operation of the fuel injection valve is assured.

Advantageous further developments of the fuel injection valve indicated in the main claim are possible by implementing the measures listed in the subclaims.

The simple design of the components from the point of view of manufacturing technology is advantageous. In particular the enclosing and prestressing of the actuator in an actuator housing are advantageous, since the thermal change in length of the actuator does not need to be compensated for by expensive material combinations, but is compensated for by a prestress spring. Thus the entire length of the actuator housing is unaffected by thermal changes in length. Thus by uncoupling the actuator and the valve housing, only a change in position of the actuator housing relative to the valve housing still needs to be compensated for.

The enclosing of a readjusting spring and damping element in a valve shell is also advantageous because of the resulting compact construction.

Brief Description Of The Drawings

Figure 1 shows an axial section through a first exemplary embodiment of a fuel injection valve of the present invention.

Figure 2 shows an axial section through a second exemplary embodiment of a fuel injection valve of the present invention.

Detailed Description

Figure 1 shows a first exemplary embodiment of fuel injection valve 1 of the present invention in axial section. This is a fuel injection valve 1 that opens inwards.

Ring-shaped actuator 3 having central recess 7 made of disk-shaped piezoelectric or magnetostrictive elements 4 and prestress spring 5 are arranged in actuator housing 2. Actuator 3 is operated by an electronic control unit via a plug contact (not shown). For the sake of simplification, only a single connection wire 6 is shown in Figure 1.

Actuator housing 2 is made of shell 8 and actuator housing cover 9. Actuator housing cover 9 rests against first end 10 of prestress spring 5. First face 11 of actuator 3 rests against an end of shell 8 on the spraying side, actuator 3 being surrounded radially by shell 8. Second face 12 of actuator 3 and second end 13 of prestress spring 5 are supported against intermediary center flange 14. Actuator 3 is prestressed by prestress spring 5 via shell 8.

Center flange 14 is preferably connected frictionally with actuating body 16 by welded seam 15. Actuating body 16 is arranged in central recess 7 of actuator 3 and is connected to valve needle 17 on which valve closing body 18 is formed. When valve closing body 18 is lifted away from valve seat surface 19, fuel is sprayed through spray aperture 20 formed in valve seat body 29. Actuating body 16 is supported at its end against readjusting spring 21. The fuel flows to the seat via fuel inlet 22 of valve housing 23 formed close to the seat and via space 24 between valve needle 17 and valve housing 23.

First ring-shaped damping element 25a is located at first end 39 of actuator housing 2, between shell 8 of actuator housing 2 and valve housing 23. Second ring-shaped damping element 25b is located at second end 40 of actuator housing 2, between actuator housing cover 9 of actuator housing 2 and valve housing 23. Damping elements 25a, 25b are made of a plastic, in particular of uncured silicone rubber, which exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate. Damping elements 25a, 25b have mechanical springs 27 whose damping behavior is superimposed on the damping behavior of the plastic. The plastic is advantageously enclosed in jacket 26. Damping elements 25a, 25b buffer actuator housing 2 against valve housing 23.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention shown in Figure 1, disk-shaped elements 4 of actuator 3 expand, causing center flange 14 to be moved against the direction of flow of the fuel. Prestress spring 5 is compressed further against the prestress already present. Valve closing body 18 lifts from valve seat surface 19 and fuel is sprayed through spray aperture 20 formed in valve seat body 29.

During the operation of fuel injection valve 1 of the present invention in an internal combustion engine, the high actuating frequency of actuator 3 causes damping elements 25a, 25b located between valve housing 23 and actuator housing 2 to behave like an incompressible solid, since when actuator 3 is set in motion it expands too fast for damping elements 25a, 25b to be compressed. The behavior of damping elements 25a, 25b is almost static, causing the pulse initiated by the electrical activating voltage to be transmitted to actuating body 16 and fuel injection valve 1 to open.

Fuel injection valve 1 experiences severe temperature fluctuations during operation. On the one hand, the entire fuel injection valve 1 is heated by contact with the combustion chamber of an internal combustion engine; on the other hand local temperature changes occur caused, e.g., by the power loss during deformation of piezoelectric actuator 3 or by electrical charge movement. This results in a thermal shortening in length of disk-shaped elements 4, since piezoelectric ceramics have negative temperature expansion coefficients, i.e., they contract when heated and expand when cooled.

Such a shortening of actuator 3 by heating is compensated for within actuator housing 2 by the expansion of prestressed spring 5. The shortening of actuator 3 leads to an elongation of prestress spring 5. Since center flange 14 is arrested at actuating body 16 via welded seam 15, a change in position of actuator housing 2 results from the change in length of actuator 3. This change in position of actuator housing 2 is compensated for by the buffering of actuator housing 2 within valve housing 23 by damping elements 25a, 25b, since, during the quasi-static changes in position of actuator housing 2 relative to valve housing 23 due to temperature influences, actuator housing 2 moves so slowly that damping elements 25a, 25b are deformed elastically or plastically.

Figure 2 shows in an axial section a second exemplary embodiment of fuel injection valve 1 of the present invention. Already described elements are provided with corresponding reference numbers, so that a repeated description is unnecessary.

In this exemplary embodiment, actuator 3 rests at its second face 12 against actuator housing cover 30, against which prestress spring 5 is supported and is clamped between actuator housing cover 30 and valve housing cover 28. Actuator 3 is supported at its first face 11 against flange 31, which is operably connected to valve housing 23 by welded seam 32. Actuating body 16 is mounted on actuator housing cover 30 and is conducted through central recess 7 of actuator 3.

Actuating body 16 projects at one end into valve shell 33. In valve shell 33 readjusting spring 21 and damping element 25 are enclosed so that readjusting spring 21 and damping element 25 are supported against intermediary valve needle flange 34. Readjusting spring 21 is clamped between cover plate 38 of valve shell 33 and valve needle flange 34. Valve needle flange 34 and valve needle 17, which projects through recess 35 in base plate 37 of valve shell 33, are formed in one piece. Valve needle 17 is conducted through valve needle guide 36. Valve closing body 18, which forms a seat with valve seat surface 19, forms the termination of valve needle 17. The fuel is fed via a lateral fuel inlet 22 and flows to the seat via space 24 between valve needle 17 and valve housing 23. At least one spray aperture 20 is formed in valve seat body 29.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention, piezoelectric elements 4 of actuator 3 expand. Since actuator 3 at its first face 11 rests against flange 31, which is connected permanently to valve housing 23 via welded seam 32, it expands in the lift direction and entrains actuating body 16 in the lift direction. Due to the hard transmission behavior of damping element 25, actuating body 16, operably connected to valve shell 33, entrains valve needle 17 via valve needle flange 34 and thus opens fuel injection valve 1.

The hard transmission behavior of damping element 25 is caused by the high switching speed of actuator 3. When actuator 3 is set in motion, actuating body 16 moves so quickly that damping element 25 behaves like an incompressible solid and transmits the pulse to valve needle flange 34 and valve needle 17. However, fuel injection valve 1 is also subject to a heat expansion. During this slow change in length of actuator 3, damping element 25 exhibits a soft transmission behavior. When actuating body 16 is displaced by a quasi-static thermal change in length of actuator 3, the movement is compensated for by damping element 25 in that damping element 25 is compressed and valve closing body 18 is pressed against valve seat surface 19 by prestress spring 5 via valve needle flange 34.

The present invention is not limited to the exemplary embodiments shown; it can also be implemented with a plurality of other constructions of fuel injection valves 1.

Abstract Of The Disclosure

A fuel injection valve, in particular an injection valve for fuel injection systems of internal combustion engines, is made of a piezoelectric or magnetostrictive actuator and a valve closing body that can be set in motion by the actuator via a valve needle and that interacts with a valve seat surface to produce a seat. To compensate for the temperature expansion, at least one damping element made of a solid is present and exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate.

FUEL INJECTION VALVE

Field Of The Invention

The present invention [is based on] relates to a fuel injection valve. [in accordance with the species of the main claim]

Background Information

Usually changes in the length of a piezoelectric actuator of a fuel injection valve caused by temperature influences are compensated for via hydraulic devices or by selecting suitable combinations of materials.

A fuel injection valve in which the change in length of the actuator is compensated for by an appropriate combination of materials is known from German Patent No. 197 02 066 [C2]. The fuel injection valve arising from this publication has an actuator that is conducted in the valve housing under spring prestress and that interacts with an actuating part made of an actuating body and a head part, the head part lying on the piezoelectric actuator and the actuating body penetrating an inner recess of the actuator. The actuating body is operably connected to a valve needle. When the actuator is set in motion, the valve needle is actuated against the direction of spraying.

The actuator and the actuating body have at least approximately the same length and are made of a ceramic material or of a material similar to ceramic with respect to its thermal expansion. The result of using materials having the same lengths and thermal expansion coefficients, e.g., INVAR, is that the actuator and the actuating body expand uniformly under the influence of heat and thus do not have an adverse effect on the opening and closing times.

An undesired opening of the fuel injection valve between the switching pulses is also avoided. The disadvantage of this arrangement is above all its limited usability in systems that are subject to large fluctuations in temperature. The arrangement known from German Patent No. 197 02 066 [C2] does not achieve the objective due to the nonlinear behavior of the temperature expansion coefficients of piezoelectric ceramics over the temperature curve. As a result, imprecise fuel metering times and amounts occur.

Another disadvantage is the high manufacturing effort required, which is associated with relatively high costs caused in particular by the selection of the materials (e.g., INVAR).

[Advantages of the Present] Summary Of The Invention

The fuel injection valve of the present invention with the characterizing features of the main claim, on the other hand, has the advantage that the temperature compensation is independent of the thermal expansion coefficient of the piezoelectric ceramic. The thermal expansion is compensated for via damping elements having a speed-dependent transmission behavior for arriving pulses and is thus independent of the selection of the material for the actuating element and valve housing. Thus a secure and precise method of operation of the fuel injection valve is assured.

Advantageous further developments of the fuel injection valve indicated in the main claim are possible by implementing the measures listed in the subclaims.

The simple design of the components from the point of view of manufacturing technology is advantageous. In particular the enclosing and prestressing of the actuator in an actuator housing are advantageous, since the thermal change in length of the actuator does not need to be compensated for by expensive material combinations, but is compensated for by a prestress spring. Thus the entire length of the actuator housing is unaffected by thermal changes in length. Thus by uncoupling the actuator and the valve housing, only a change in position of the actuator housing relative to the valve housing still needs to be compensated for.

The enclosing of a readjusting spring and damping element in a valve shell is also advantageous because of the resulting compact construction.

Brief Description Of The Drawings

[Exemplary embodiments of the present invention are shown in simplified form in the drawings and are explained in greater detail in the subsequent description.]

Figure 1 shows an axial section through a first exemplary embodiment of a fuel injection valve of the present invention [and].

Figure 2 shows an axial section through a second exemplary embodiment of a fuel injection valve of the present invention.

[Exemplary Embodiments] Detailed Description

Figure 1 shows a first exemplary embodiment of fuel injection valve 1 of the present invention in axial section. This is a fuel injection valve 1 that opens inwards.

Ring-shaped actuator 3 having central recess 7 made of disk-shaped piezoelectric or magnetostrictive elements 4 and prestress spring 5 are arranged in actuator housing 2. Actuator 3 is operated by an electronic control unit via a plug contact (not shown). For the sake of simplification, only a single connection wire 6 is shown in Figure 1.

Actuator housing 2 is made of shell 8 and actuator housing cover 9. Actuator housing cover 9 rests against first end 10 of prestress spring 5. First face 11 of actuator 3 rests against an end of shell 8 on the spraying side, actuator 3 being surrounded radially by shell 8. Second face 12 of actuator 3 and second end 13 of prestress spring 5 are supported against intermediary center flange 14. Actuator 3 is prestressed by prestress spring 5 via shell 8.

Center flange 14 is preferably connected frictionally with actuating body 16 by welded seam 15. Actuating body 16 is arranged in central recess 7 of actuator 3 and is connected to valve needle 17 on which valve closing body 18 is formed. When valve closing body 18 is lifted

away from valve seat surface 19, fuel is sprayed through spray aperture 20 formed in valve seat body 29. Actuating body 16 is supported at its end against readjusting spring 21. The fuel flows to the seat via fuel inlet 22 of valve housing 23 formed close to the seat and via space 24 between valve needle 17 and valve housing 23.

First ring-shaped damping element 25a is located at first end 39 of actuator housing 2, between shell 8 of actuator housing 2 and valve housing 23. Second ring-shaped damping element 25b is located at second end 40 of actuator housing 2, between actuator housing cover 9 of actuator housing 2 and valve housing 23. Damping elements 25a, 25b are made of a plastic, in particular of uncured silicone rubber, which exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate. Damping elements 25a, 25b have mechanical springs 27 whose damping behavior is superimposed on the damping behavior of the plastic. The plastic is advantageously enclosed in jacket 26. Damping elements 25a, 25b buffer actuator housing 2 against valve housing 23.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention shown in Figure 1, disk-shaped elements 4 of actuator 3 expand, causing center flange 14 to be moved against the direction of flow of the fuel. Prestress spring 5 is compressed further against the prestress already present. Valve closing body 18 lifts from valve seat surface 19 and fuel is sprayed through spray aperture 20 formed in valve seat body 29.

During the operation of fuel injection valve 1 of the present invention in an internal combustion engine, the high actuating frequency of actuator 3 causes damping elements 25a, 25b located between valve housing 23 and actuator housing 2 to behave like an incompressible solid, since when actuator 3 is set in motion it expands too fast for damping elements 25a, 25b to be compressed. The behavior of damping elements 25a, 25b is almost static, causing the pulse initiated by the electrical activating voltage to be transmitted to actuating body 16 and fuel injection valve 1 to open.

Fuel injection valve 1 experiences severe temperature fluctuations during operation. On the one hand, the entire fuel injection valve 1 is heated by contact with the combustion chamber of an internal combustion engine; on the other hand local temperature changes occur caused,

e.g., by the power loss during deformation of piezoelectric actuator 3 or by electrical charge movement. This results in a thermal shortening in length of disk-shaped elements 4, since piezoelectric ceramics have negative temperature expansion coefficients, i.e., they contract when heated and expand when cooled.

Such a shortening of actuator 3 by heating is compensated for within actuator housing 2 by the expansion of prestressed spring 5. The shortening of actuator 3 leads to an elongation of prestress spring 5. Since center flange 14 is arrested at actuating body 16 via welded seam 15, a change in position of actuator housing 2 results from the change in length of actuator 3. This change in position of actuator housing 2 is compensated for by the buffering of actuator housing 2 within valve housing 23 by damping elements 25a, 25b, since, during the quasi-static changes in position of actuator housing 2 relative to valve housing 23 due to temperature influences, actuator housing 2 moves so slowly that damping elements 25a, 25b are deformed elastically or plastically.

Figure 2 shows in an axial section a second exemplary embodiment of fuel injection valve 1 of the present invention. Already described elements are provided with corresponding reference numbers, so that a repeated description is unnecessary.

In this exemplary embodiment, actuator 3 rests at its second face 12 against actuator housing cover 30, against which prestress spring 5 is supported and is clamped between actuator housing cover 30 and valve housing cover 28. Actuator 3 is supported at its first face 11 against flange 31, which is operably connected to valve housing 23 by welded seam 32. Actuating body 16 is mounted on actuator housing cover 30 and is conducted through central recess 7 of actuator 3.

Actuating body 16 projects at one end into valve shell 33. In valve shell 33 readjusting spring 21 and damping element 25 are enclosed so that readjusting spring 21 and damping element 25 are supported against intermediary valve needle flange 34. Readjusting spring 21 is clamped between cover plate 38 of valve shell 33 and valve needle flange 34. Valve needle flange 34 and valve needle 17, which projects through recess 35 in base plate 37 of valve shell 33, are formed in one piece. Valve needle 17 is conducted through valve needle guide

36. Valve closing body 18, which forms a seat with valve seat surface 19, forms the termination of valve needle 17. The fuel is fed via a lateral fuel inlet 22 and flows to the seat via space 24 between valve needle 17 and valve housing 23. At least one spray aperture 20 is formed in valve seat body 29.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention, piezoelectric elements 4 of actuator 3 expand. Since actuator 3 at its first face 11 rests against flange 31, which is connected permanently to valve housing 23 via welded seam 32, it expands in the lift direction and entrains actuating body 16 in the lift direction. Due to the hard transmission behavior of damping element 25, actuating body 16, operably connected to valve shell 33, entrains valve needle 17 via valve needle flange 34 and thus opens fuel injection valve 1.

The hard transmission behavior of damping element 25 is caused by the high switching speed of actuator 3. When actuator 3 is set in motion, actuating body 16 moves so quickly that damping element 25 behaves like an incompressible solid and transmits the pulse to valve needle flange 34 and valve needle 17. However, fuel injection valve 1 is also subject to a heat expansion. During this slow change in length of actuator 3, damping element 25 exhibits a soft transmission behavior. When actuating body 16 is displaced by a quasi-static thermal change in length of actuator 3, the movement is compensated for by damping element 25 in that damping element 25 is compressed and valve closing body 18 is pressed against valve seat surface 19 by prestress spring 5 via valve needle flange 34.

The present invention is not limited to the exemplary embodiments shown; it can also be implemented with a plurality of other constructions of fuel injection valves 1.

Abstract Of The Disclosure

A fuel injection valve[(1)], in particular an injection valve for fuel injection systems of internal combustion engines, is made of a piezoelectric or magnetostrictive actuator [(3)] and a valve closing body [(18)] that can be set in motion by the actuator [(3)] via a valve needle [(17)] and that interacts with a valve seat surface [(19)] to produce a seat. To compensate for the temperature expansion, at least one damping element [(25a, 25b)] made of a solid is present and exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate.

[(Figure 1)]

N/PRTS

09/857335
JC18 Rec'd PCT/PTO 04 JUN 2001

[10191/1885]

FUEL INJECTION VALVE

Background Information

The present invention is based on a fuel injection valve in accordance with the species of the main claim.

Usually changes in the length of a piezoelectric actuator of a fuel injection valve caused by temperature influences are compensated for via hydraulic devices or by selecting suitable combinations of materials.

A fuel injection valve in which the change in length of the actuator is compensated for by an appropriate combination of materials is known from German Patent 197 02 066 C2. The fuel injection valve arising from this publication has an actuator that is conducted in the valve housing under spring prestress and that interacts with an actuating part made of an actuating body and a head part, the head part lying on the piezoelectric actuator and the actuating body penetrating an inner recess of the actuator. The actuating body is operably connected to a valve needle. When the actuator is set in motion, the valve needle is actuated against the direction of spraying.

The actuator and the actuating body have at least approximately the same length and are made of a ceramic material or of a material similar to ceramic with respect to its thermal expansion. The result of using materials having the same lengths and thermal expansion coefficients, e.g., INVAR, is that the actuator and the actuating body expand uniformly under the influence of heat and thus do not have an adverse effect on the opening and closing times. An undesired opening of the fuel injection valve between the switching pulses is also avoided.

The disadvantage of this arrangement is above all its limited usability in systems that are subject to large fluctuations in temperature. The arrangement known from German Patent 197 02 066 C2 does not achieve the objective due to the nonlinear behavior of the temperature expansion coefficients of piezoelectric ceramics over the temperature curve. As a result, imprecise fuel metering times and amounts occur.

Another disadvantage is the high manufacturing effort required, which is associated with relatively high costs caused in particular by the selection of the materials (e.g., INVAR).

Advantages of the Present Invention

The fuel injection valve of the present invention with the characterizing features of the main claim, on the other hand, has the advantage that the temperature compensation is independent of the thermal expansion coefficient of the piezoelectric ceramic. The thermal expansion is compensated for via damping elements having a speed-dependent transmission behavior for arriving pulses and is thus independent of the selection of the material for the actuating element and valve housing. Thus a secure and precise method of operation of the fuel injection valve is assured.

Advantageous further developments of the fuel injection valve indicated in the main claim are possible by implementing the measures listed in the subclaims.

The simple design of the components from the point of view of manufacturing technology is advantageous. In particular the enclosing and prestressing of the actuator in an actuator housing are advantageous, since the thermal change in length of the actuator does not need to be compensated for by expensive material combinations, but is compensated for by a prestress spring. Thus the entire length of the actuator housing is unaffected by thermal changes in length. Thus by uncoupling the actuator and the valve housing, only a change in position of the actuator housing relative to the valve housing still needs to be compensated for.

The enclosing of a readjusting spring and damping element in a valve shell is also advantageous because of the resulting compact construction.

Drawings

Exemplary embodiments of the present invention are shown in simplified form in the drawings and are explained in greater detail in the subsequent description.

Figure 1 shows an axial section through a first exemplary embodiment of a fuel injection valve of the present invention and

Figure 2 shows an axial section through a second exemplary embodiment of a fuel injection valve of the present invention.

Exemplary Embodiments

Figure 1 shows a first exemplary embodiment of fuel injection valve 1 of the present invention in axial section. This is a fuel injection valve 1 that opens inwards.

Ring-shaped actuator 3 having central recess 7 made of disk-shaped piezoelectric or magnetostrictive elements 4 and prestress spring 5 are arranged in actuator housing 2. Actuator 3 is operated by an electronic control unit via a plug contact (not shown). For the sake of simplification, only a single connection wire 6 is shown in Figure 1.

Actuator housing 2 is made of shell 8 and actuator housing cover 9. Actuator housing cover 9 rests against first end 10 of prestress spring 5. First face 11 of actuator 3 rests against an end of shell 8 on the spraying side, actuator 3 being surrounded radially by shell 8. Second face 12 of actuator 3 and second end 13 of prestress spring 5 are supported against intermediary center flange 14. Actuator 3 is prestressed by prestress spring 5 via shell 8.

Center flange 14 is preferably connected frictionally with actuating body 16 by welded seam 15. Actuating body 16 is arranged in central recess 7 of actuator 3 and is connected to valve needle 17 on which valve closing body 18 is formed. When valve closing body 18 is lifted away from valve seat surface 19, fuel is sprayed through spray aperture 20 formed in valve seat body 29. Actuating body 16 is supported at its end against readjusting spring 21. The fuel

flows to the seat via fuel inlet 22 of valve housing 23 formed close to the seat and via space 24 between valve needle 17 and valve housing 23.

First ring-shaped damping element 25a is located at first end 39 of actuator housing 2, between shell 8 of actuator housing 2 and valve housing 23. Second ring-shaped damping element 25b is located at second end 40 of actuator housing 2, between actuator housing cover 9 of actuator housing 2 and valve housing 23. Damping elements 25a, 25b are made of a plastic, in particular of uncured silicone rubber, which exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate. Damping elements 25a, 25b have mechanical springs 27 whose damping behavior is superimposed on the damping behavior of the plastic. The plastic is advantageously enclosed in jacket 26. Damping elements 25a, 25b buffer actuator housing 2 against valve housing 23.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention shown in Figure 1, disk-shaped elements 4 of actuator 3 expand, causing center flange 14 to be moved against the direction of flow of the fuel. Prestress spring 5 is compressed further against the prestress already present. Valve closing body 18 lifts from valve seat surface 19 and fuel is sprayed through spray aperture 20 formed in valve seat body 29.

During the operation of fuel injection valve 1 of the present invention in an internal combustion engine, the high actuating frequency of actuator 3 causes damping elements 25a, 25b located between valve housing 23 and actuator housing 2 to behave like an incompressible solid, since when actuator 3 is set in motion it expands too fast for damping elements 25a, 25b to be compressed. The behavior of damping elements 25a, 25b is almost static, causing the pulse initiated by the electrical activating voltage to be transmitted to actuating body 16 and fuel injection valve 1 to open.

Fuel injection valve 1 experiences severe temperature fluctuations during operation. On the one hand, the entire fuel injection valve 1 is heated by contact with the combustion chamber of an internal combustion engine; on the other hand local temperature changes occur caused, e.g., by the power loss during deformation of piezoelectric actuator 3 or by electrical charge movement. This results in a thermal shortening in length of disk-shaped elements 4, since

piezoelectric ceramics have negative temperature expansion coefficients, i.e., they contract when heated and expand when cooled.

Such a shortening of actuator 3 by heating is compensated for within actuator housing 2 by the expansion of prestressed spring 5. The shortening of actuator 3 leads to an elongation of prestress spring 5. Since center flange 14 is arrested at actuating body 16 via welded seam 15, a change in position of actuator housing 2 results from the change in length of actuator 3. This change in position of actuator housing 2 is compensated for by the buffering of actuator housing 2 within valve housing 23 by damping elements 25a, 25b, since, during the quasi-static changes in position of actuator housing 2 relative to valve housing 23 due to temperature influences, actuator housing 2 moves so slowly that damping elements 25a, 25b are deformed elastically or plastically.

Figure 2 shows in an axial section a second exemplary embodiment of fuel injection valve 1 of the present invention. Already described elements are provided with corresponding reference numbers, so that a repeated description is unnecessary.

In this exemplary embodiment, actuator 3 rests at its second face 12 against actuator housing cover 30, against which prestress spring 5 is supported and is clamped between actuator housing cover 30 and valve housing cover 28. Actuator 3 is supported at its first face 11 against flange 31, which is operably connected to valve housing 23 by welded seam 32. Actuating body 16 is mounted on actuator housing cover 30 and is conducted through central recess 7 of actuator 3.

Actuating body 16 projects at one end into valve shell 33. In valve shell 33 readjusting spring 21 and damping element 25 are enclosed so that readjusting spring 21 and damping element 25 are supported against intermediary valve needle flange 34. Readjusting spring 21 is clamped between cover plate 38 of valve shell 33 and valve needle flange 34. Valve needle flange 34 and valve needle 17, which projects through recess 35 in base plate 37 of valve shell 33, are formed in one piece. Valve needle 17 is conducted through valve needle guide 36. Valve closing body 18, which forms a seat with valve seat surface 19, forms the termination of valve needle 17. The fuel is fed via a lateral fuel inlet 22 and flows to the seat

via space 24 between valve needle 17 and valve housing 23. At least one spray aperture 20 is formed in valve seat body 29.

When an electrical activating voltage is applied to actuator 3 of fuel injection valve 1 of the present invention, piezoelectric elements 4 of actuator 3 expand. Since actuator 3 at its first face 11 rests against flange 31, which is connected permanently to valve housing 23 via welded seam 32, it expands in the lift direction and entrains actuating body 16 in the lift direction. Due to the hard transmission behavior of damping element 25, actuating body 16, operably connected to valve shell 33, entrains valve needle 17 via valve needle flange 34 and thus opens fuel injection valve 1.

The hard transmission behavior of damping element 25 is caused by the high switching speed of actuator 3. When actuator 3 is set in motion, actuating body 16 moves so quickly that damping element 25 behaves like an incompressible solid and transmits the pulse to valve needle flange 34 and valve needle 17. However, fuel injection valve 1 is also subject to a heat expansion. During this slow change in length of actuator 3, damping element 25 exhibits a soft transmission behavior. When actuating body 16 is displaced by a quasi-static thermal change in length of actuator 3, the movement is compensated for by damping element 25 in that damping element 25 is compressed and valve closing body 18 is pressed against valve seat surface 19 by prestress spring 5 via valve needle flange 34.

The present invention is not limited to the exemplary embodiments shown; it can also be implemented with a plurality of other constructions of fuel injection valves 1.

What is claimed is:

1. A fuel injection valve (1), in particular an injection valve for fuel injection systems of internal combustion engines, having a piezoelectric or magnetostrictive actuator (3) and a valve closing body (18) that can be activated by the actuator (3) via a valve needle (17) and that interacts with a valve seat surface (19) to produce a sealing seat,

wherein

at least one damping element (25; 25a, 25b) is present having a solid that exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate.

2. The fuel injection valve as recited in Claim 1,

wherein

the solid of the damping element (25; 25a, 25b) is made of a plastic, in particular of uncured silicone rubber.

3. The fuel injection valve as recited in Claim 2,

wherein

the damping element (25; 25a, 25b) has a mechanical spring (27) whose damping behavior is superimposed on the damping behavior of the plastic.

4. The fuel injection valve as recited in any of Claims 1 to 3,

wherein

a first face (11) of the actuator (3) is supported against a shell (8), a prestress spring (5) rests with a first end (10) against an actuator housing cover (9) that terminates the shell (8) to produce an actuator housing (2), and a second face (12) of the actuator (3) and a second end (13) of the prestress spring (5) are supported against a center flange (14).

5. The fuel injection valve as recited in Claim 4,

wherein

the actuator housing (2) together with the actuator (3) contained therein and the prestress spring (5) has a constant length and is supported against a valve housing (23) with a first end

(39) via a first ring-shaped damping element (25a) and with a second end (40) via a second ring-shaped damping element (25b).

6. The fuel injection valve as recited in Claim 5,

wherein

the valve needle (17) is connected to the center flange (14) preferably via a welded seam (15).

7. The fuel injection valve as recited in any of Claims 1 to 3,

wherein

the actuator (3) is supported with a first face (11) against a flange (31) and with its second face (12) against a cover plate (30).

8. The fuel injection valve as recited in Claim 7,

wherein

the flange (31) is connected to a valve housing (23), preferably via a welded seam (32).

9. The fuel injection valve as recited in either of Claims 7 or 8,

wherein

an actuating body (16) supported at one end against the cover plate (30) is operably connected to the valve needle (17) via a valve shell (33).

10. The fuel injection valve as recited in Claim 9,

wherein

a readjusting spring (21) and a flange (34) of the valve needle (17) are enclosed in the valve shell (33), a damping element (25) being arranged between the valve needle flange (34) and a base plate (37) of the valve shell (33), and the readjusting spring (21) being clamped between the valve needle flange (34) and a cover plate (38) of the valve shell (33).

11. The fuel injection valve as recited in Claim 10,

wherein

a recess (35), through which the valve needle (17) extends, is located in the base plate (37) of the valve shell (33).

12. The fuel injection valve as recited in any of the previous Claims,

wherein

the actuator (3) is ring-shaped having a central recess (7) through which extends an actuating body (16) that acts on the valve needle (17).

Abstract

A fuel injection valve (1), in particular an injection valve for fuel injection systems of internal combustion engines, is made of a piezoelectric or magnetostrictive actuator (3) and a valve closing body (18) that can be set in motion by the actuator (3) via a valve needle (17) and that interacts with a valve seat surface (19) to produce a seat. To compensate for the temperature expansion, at least one damping element (25a, 25b) made of a solid is present and exhibits an almost static behavior at a high deformation rate and is elastically or plastically deformable at a low deformation rate.

(Figure 1)

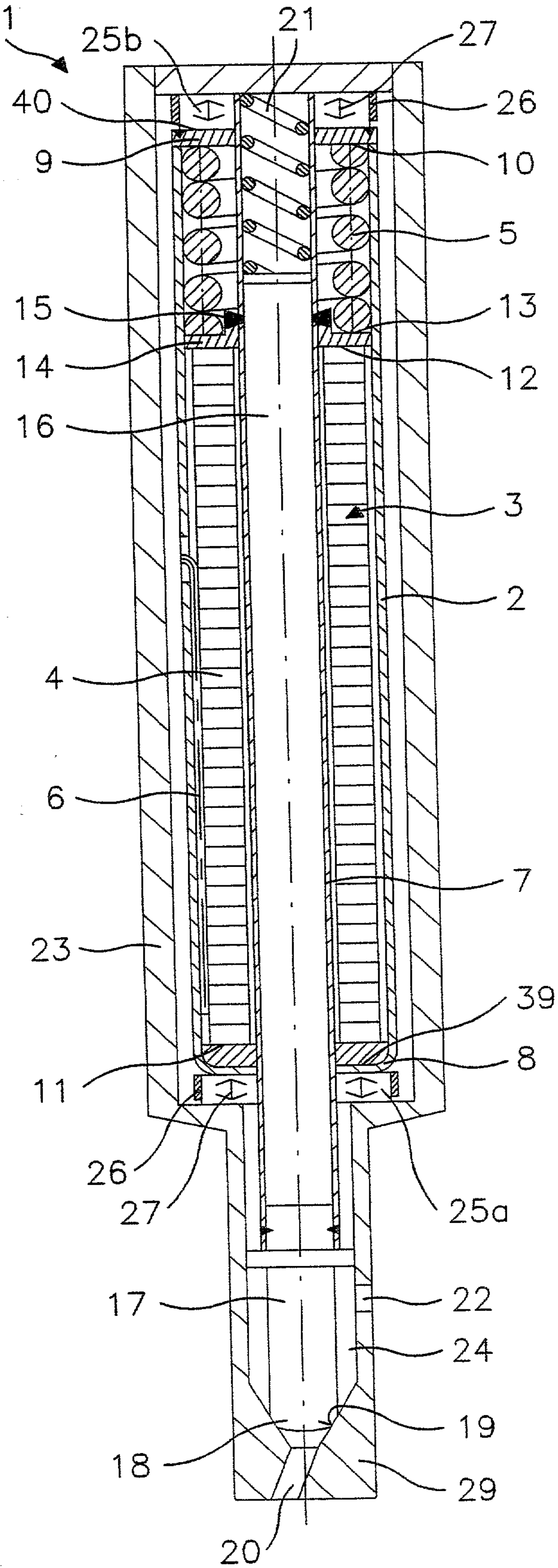
1
25b
21
27
40
26
9
10
5
15
13
14
12
16
3
2
4
6
7
23
39
11
8
26
27
25a
17
22
24
19
18
29
20

Fig. 1

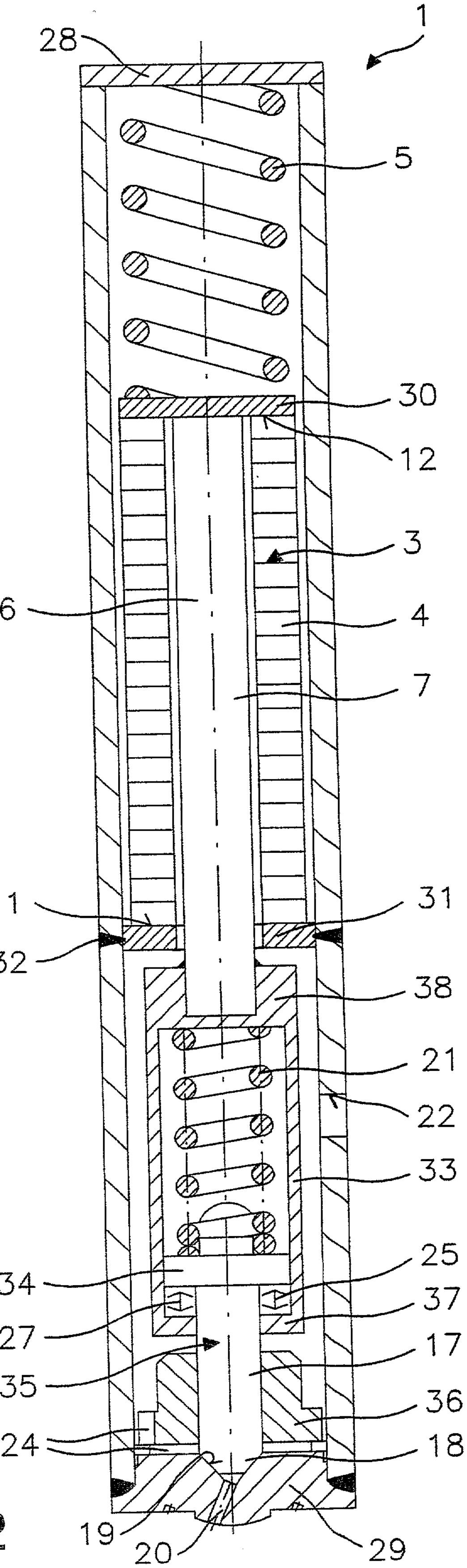
28
1
5
30
12
3
16
4
7
11
31
32
38
21
22
33
34
25
37
27
17
35
36
24
18
19
20
29

Fig. 2

[10191/1885]

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **FUEL INJECTION VALVE**, and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No.
and,

[x] was filed as PCT International Application Number PCT/DE00/03452, on the 29th day of September, 2000

[ ] an English translation was previously submitted.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

~~EL244503965~~
EL244506215US

PRIOR FOREIGN/PCT APPLICATION(S)
<u>AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119</u>

Country : Federal Republic of Germany

Application No. : 199 47 779.5

Date of Filing: 02 October 1999

Priority Claimed
Under 35 U.S.C. § 119 : [x] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR
PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

<u>U.S. APPLICATIONS</u>

Number :

Filing Date :

PCT APPLICATIONS
<u>DESIGNATING THE U.S.</u>

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

(List name(s) and registration number(s)):

Richard L. Mayer, Reg. No. 22,490
Gerard A. Messina, Reg. No. 35,952

All correspondence should be sent to:

Richard L. Mayer, Esq.
Kenyon & Kenyon
One Broadway
New York, New York 10004

Telephone No.: (212) 425-7200
Facsimile No.: (212) 425-5288

CUSTOMER NO. 26646

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1-00

Full name of inventor **Wolfgang RUEHLE**

Inventor's signature ______ Date 6/18/01

Citizenship: Federal Republic of Germany

Residence: Steinstr. 22
71254 Ditzingen DEX
Federal Republic of Germany

Post Office Address Same as above

Full name of inventor 2-10 **Hubert STIER**

Inventor's signature Hubert Stier Date June, 19th, 2001

Citizenship: Federal Republic of Germany

Residence: Lindenweg 11
71679 Asperg DEX
Federal Republic of Germany

Post Office Address Same as above

Full name of inventor 3-00 **Matthias BOEE**

Inventor's signature ___Matthias Böe___ Date 6/19/01

Citizenship: Federal Republic of Germany

Residence: Hoernleshalde 3
71640 Ludwigsburg DEX
Federal Republic of Germany

Post Office Address___Same as above___

Full name of inventor ~~**Guenther HOHL**~~ *4 D*

Inventor's signature *Günther Hohl* Date *6/19/01*

Citizenship: Federal Republic of Germany

Residence: Knappenweg 46
70569 Stuttgart *DEX*
Federal Republic of Germany

Post Office Address Same as above

10090675.060501

Full name of inventor **Norbert KEIM**

Inventor's signature Norbert Keim Date June 19, 2001

Citizenship: Federal Republic of Germany

Residence: Traminer Weg 10
74369 Loechgau DEX
Federal Republic of Germany

Post Office Address Same as above